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Orbital liquid and spin waves in ferromagnetic manganites

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We investigate the orbital state of the e_g electrons in the ferromagnetic (FM) metallic phase of doped colossal magnetoresistance $La_{1-x}A_xMnO_3$ compounds, and its implications for the magnon spectra. The local Coulomb repulsion U between the two orbital flavours leads to an $orbital\text{-}Hubbard\ model$ filled by n electrons per site, which does not obey SU(2) invariance. Orbital ordered states, stable in Hartree-Fock approximation at large U, give anisotropic magnon spectra, contrary to experiment. By an explicit treatment of electron correlations using a slave-boson formalism we demonstrate that such states are unstable against a disordered $orbital\ liquid$ of complex orbitals: $|+\rangle = (|z\rangle - i|x\rangle)/\sqrt{2}$ and $|-\rangle = (|z\rangle + i|x\rangle)/\sqrt{2}$, where $|z\rangle = |3z^2 - r^2\rangle/\sqrt{3}$ and $|x\rangle = |x^2 - y^2\rangle$. This state explains the cubic symmetry of the spin waves observed in FM manganites at doping $x \simeq 0.30$ ($x = 1 - n$). Taking into account the double exchange due to correlated e_g electrons and superexchange promoted either by e_g or by t_{2g} hopping processes [1], and using realistic values of the e_g-hopping t and Hund's exchange J_H, we show that the effective FM interactions between spins $S = 2$ ($S = 3/2$) of Mn^{3+} (Mn^{4+}) ions and the magnon stiffness constant are proportional to x and close to the experimental values in FM metallic manganites.

[1] L. F. Feiner and A. M. Oleś, Phys. Rev. B **59**, 3295 (1999).